MODEL PREDICTION VERIFICATION STUDY

FAX, 2 pages 11/20/95
To: Janet Hashimoto
Phone: 415/744-1078
Office: Region 9

From: Walter Frick
Phone: 503/867-4029 fax 4049
USEPA

Janet: Wanted to get these off to you before I leave on vacation this aftn. at 2pm. Will be back the 27th or the 30th.

DRAFT

Walt

November 20, 1995

MEMORANDUM

SUBJECT: Joint Cannery Outfall Model Prediction Verification Study Review

FROM: Walter Frick

TO: Janet Hashimoto
Chief, Marine Protection Section

Re your memo to Henry Lee dated September 22, 1995, which was forwarded to me after some delay, I have talked to Ed Dettmann (401/782-3039) about the issues surrounding the use of WASP5. I made the following notes of my conversation with Ed:

> WASP is a suite of models ranging from one to three dimensional, i.e., it can be run at several levels of complexity ranging from DO Streeter-Phelps equations, to solving nutrient concentrations (e.g., ammonium to nitrate conversion), to, at the highest level, calculating phytoplankton biomass concentrations. In the case of the canneries, DO would be a problem.
>
> WASP, including WASP5, must be matched with a hydrodynamic model. Within EPA the model used for this purpose is often DYNHYD, which is a one-dimensional hydrodynamic model. For three-dimensional circulation, presumably some other model or set of data would have to be used to define three-dimensional transport.
>
> Individuals in the agency familiar with WASP are Ed Dettmann at Narragansett and Mike Marsh at Region 1 (410/742-3115).
>
> Ed has used WASP ~~do~~ to calculate DO concentrations in a river estuary with freshwater input. There they used salinity data and a salinity driven box model to estimate transports necessary to establish the observed salinity distribution. Thus, advection and diffusion were calculated. The approach is steady state and salinity survey data must be available. It does not work without freshwater inflow to establish a salinity distribution.

From the text on page 5-6 of the Study it seems to me that the authors are looking to WASP5 to provide three-dimensional hydrodynamical data. If this is the case, my understanding is that it will not be a three-dimensional replacement for PT121.

Other than that, I have no objection to trying to understand the dynamics of eutrophycation in the Pago Pago Inner Harbor and believe that, given data on the three-dimensional circulation in the harbor, that WASP5 can be used appropriately.

cc. Henry Lee

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

September 22, 1995

MEMORANDUM

SUBJECT: Review of Model Prediction Verification Study for the Joint Cannery Outfall in Pago Pago Harbor

FROM: Janet Hashimoto
Chief, Environmental Assessment Section

TO: Henry Lee
Acting Coastal Ecology Branch Chief
Hatfield Marine Science Center

We have been asked by our Office of Pacific Islands and Native American Programs for a review of the attached CH2M Hill document entitled *Joint Cannery Outfall Model Prediction Verification Study*. In particular, certain recommendations for modifying the original eutrophication study include substitution of a WASP5 model for a PT121 model appplication.

As these modelling efforts are a very specialized field, we ask your help by authorizing Walter Frick's assistance in reviewing those sections of the report pertaining to models. Please ignore the CH2M Hill delivery date in the enclosed letter by Steve Costa.

If you have any questions, please contact me at 415/744-1933 or David Stuart of my staff at 415/744-1937

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT

ENVIRONMENTAL RESEARCH LABORATORY · NARRAGANSETT
HATFIELD MARINE SCIENCE CENTER
NEWPORT, OREGON 97365

December 17, 1993

PACIFIC ECOSYSTEMS BRANCH
TELEPHONE: (503) 867-4040

MEMORANDUM

SUBJECT: Review of Study Plan for Joint Cannery Ocean Dumping Studies in American Samoa

FROM: Walter E. Frick Walt E Frick
Physical/Chemical Processes Team

TO: David Stuart
Region 9 (W-7-1)

The study plan consists of two parts; Part I describes bioassay toxicity tests, and Part II describes a modeling re-evaluation. I asked Janet Lamberson, one of our biologists working with amphipods, to comment on the first part. She concluded that the proposed bioassay toxicity testing plan appeared reasonable.

Concerning Part II: Without benefit of the references, I understand that fish processing wastes will be discharged from a moving vessel. The waste will be dispersed by a combination of wake mixing (including propeller action) and passive diffusion.

As I understand it, the first phase of the model re-evaluation concerns previous modeling work based on Brooks' 4/3 power law dispersion model, which is seen to be overly conservative because it includes only lateral diffusion. The re-evaluation will reestablish this model and compare results with previous findings. The bioassay tests done under Part I will be used to determine whether predicted dilutions allow survival of the test species.

Phase 2 of Part 2 is confusing. It appears to be a critique of the previous modeling approach. The earlier model and assumptions will be re-evaluated. Appropriately, the omission of longitudinal and vertical dispersion, settling, and flotation are noted. That is straight forward enough. What is not clear is what is proposed under re-evaluation of "assumptions and methodology used to chose [sic] the magnitudes of the variables describing the important physical processes." The sensitivity analysis that follows is reasonable.

Phase 3 of Part 2 will produce a new, presumably better, model. It is anticipated that the new model will be less conservative. Presumably, the authors suspect that the previous model will show, incorrectly, that standards will be exceeded. Thus, a less conservative but also more accurate model is necessary. The two approaches will be compared and "predictions will be justified and explained."

How will the differences be justified? The authors note that "Typically a set of field data is used to determine the correct values to use for the coefficients. However, this is beyond the scope of the present study and there is little or no available and appropriate data for this task." In other words, the new model cannot be verified. As such, all the talk about sensitivity is rather meaningless.

The Brooks' 4/3 power law is part of the EPA PLUMES dilution model (Baumgartner, Frick, and Roberts, 1993. Dilution models for effluent discharges, Second edition. EPA/600/R-93-/139), which includes UM and RSB. My suspicions are that the value of the dispersion coefficient that we recommend is overly conservative in many cases. It also employs only lateral diffusion. However, I suspect that since the coefficient is based on various experimental and field measurements that this one mechanism actually parameterizes longitudinal and vertical dispersion indirectly. In other words, by virtue of the fact that the coefficient is derived empirically, the other mechanisms are represented. Thus, to make their effort credible, the authors really need to find some data to verify the changes they propose.

cc: David Young

WEF:ts

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

November 1, 1993

Steven L. Costa
Project Manager
CH2M Hill
P.O. Box 12681
Oakland, CA 94604-2681

Re: Review of the Draft Joint Cannery Outfall Model Prediction Verification Study Plan

Dear Steve:

We reviewed the draft cannery outfall model prediction study plan as required by the canneries' NPDES permits and find it satisfactory. The modeling program outlined in the plan appears to address important modeling concerns: data collection, reduction and analysis; modeling; validation; calibration; and verification. Walter Frick, an expert in hydrographic modeling at EPA's Environmental Research Laboratory in Newport Oregon, also reviewed the plan, and had the following comments:

- While he thought the UDHKDEN model will give sufficiently conservative estimates of initial dilution, with the imminent publication of "Dilution Models for Effluent Discharges" (Second Edition, EPA/600/R-93/139, July 1993), he recommended the use of UM over UDKHDEN. He felt that the results would be somewhat more realistic beyond the trapping level and, as an extra benefit, it makes provisions for including background concentrations.

- Regarding the quality assurance section, he found it largely satisfactory, but cautioned that some attention should be paid to the quality of the field data, particularly salinity and temperature stratification data. He also felt that sensitivity analyses, as described, were important but that tuning should be kept to a minimum.

We would appreciate your response to Dr. Frick's comment regarding the use of the UM model. Should you have any questions regarding the UM model, you can contact Dr. Frick at (503) 867-4029.

SYMBOL	E-4					
SURNAME	Hyorings	By for NLL				
DATE	11/1/93					

U.S. EPA CONCURRENCES

OFFICIAL FILE COPY

Sincerely,

for Pat Young
Norman L. Lovelace, Chief
Office of Pacific Island and Native
American Programs (E-4)

cc: Jim Cox, Van Camp Seafood Company
Norman Wei, StarKist Seafood Company
Tony Tausaga, American Samoa EPA
Sheila Wiegman, American Samoa EPA

bc: Robyn Stuber, W-5-1
Dave Stuart, W-7-1
Mike Lee, E-4

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL	# of pages ▶ 1
To Dave Stuart	From Walter Frick
Dept./Agency Region 9	Phone # (503) 867-4029
Fax # (415) 744-1072	Fax # 4049
NSN 7540-01-317-7368 5099-101	GENERAL SERVICES ADMINISTRATION

November 1, 1993

MEMORANDUM

SUBJECT: Comments on Steve Costa 27 Aug 93 letter: Joint Cannery Outfall Model Prediction Verification Study Plan

FROM: Walter E. Frick

TO: David Stuart
Region 9

I have read the subject report and find it functionally satisfactory but repetitive and confusing on a literary level. I hope ensuing program reports will be written with greater focus and clarity.

The modeling program outlined in this study plan appears to address important modeling concerns: data collection, reduction, and analysis, modeling, validation, calibration, and verification.

I'm aware of CH2M's attachment to UDKHDEN and I think the model will give sufficiently conservative estimates of initial dilution. However, with the publication of "Dilution Models for Effluent Discharges (Second Edition)" (EPA/600/R-93/139, July 1993) imminent, I recommend the use of UM over UDKHDEN. I think the results will be somewhat more realistic beyond the trapping level and, as an extra benefit, it makes provisions for including background concentrations.

The capabilities of the PT121 Model appear to be commensurate with the problem of transport in the harbor. However, I have no first hand experience with it.

The section on quality assurance is largely satisfactory. However, some attention should be paid to the quality of the field data, particularly salinity and temperature stratification data. Sensitivity analyses, as described, are important but tuning should be kept to a minimum. Extrapolation also presents potential problems, as noted.

cc: David Young

Rcd 8/31/93
Copy to Janet H.,
Terry Oda

CH2M HILL Engineers Planners Economists Scientists

27 August 1993

PDX30702.MD.SP

Patricia N.N. Young
American Samoa Program Manager
Office of Pacific Islands and Native American Programs
U.S. Environmental Protection Agency
75 Hawthorne Street (E-4)
San Francisco, California 94105

Dear Pat:

Subject: Joint Cannery Outfall **Model Prediction Verification Study Plan**

Attached is a draft study plan for the model prediction verification study required by the NPDES permits for the Joint Cannery Outfall in Pago Pago Harbor, American Samoa. This study plan is for review by USEPA and ASEPA and is intended to comply with Part H of NPDES Permit Numbers AS0000019 and AS0000027. The model study plan is being submitted well ahead of schedule so that the eutrophication study and the modeling study can be conducted concurrently.

I am sending three copies by mail to facilitate distribution to reviewers. Please provide your comments on the study plan directly to me and to Norman Wei at StarKist and Jim Cox at Van Camp. If you or other reviewers have any questions, please feel free to call me at your convenience. I have sent the same material to Sheila Wiegman at ASEPA.

Thank you for your time and attention to this matter.

Sincerely,

CH2M HILL

Steve Costa

Steven L. Costa
Project Manager

cc: Norman Wei/StarKist Seafood Company
James Cox/Van Camp Seafood Company

CH2M HILL 1111 Broadway, Suite 1200, Oakland, CA 94607-4046
P.O. Box 12681, Oakland, CA 94604-2681
510 251-2426
Fax No. 510 893-8205

AGENCY REVIEW DRAFT

JOINT CANNERY OUTFALL
MODEL PREDICTION VERIFICATION
STUDY PLAN

for

StarKist Samoa, Inc.
and
VCS Samoa Packing Company

to comply with NPDES Permits

AS0000019
and
AS0000027

August 1993

prepared by

CH2M HILL

JOINT CANNERY OUTFALL MODEL PREDICTION VERIFICATION STUDY PLAN

INTRODUCTION

This study plan describes the rationale and approach of the model prediction verification study for the Joint Cannery Outfall (JCO) in Pago Pago Harbor, American Samoa. The purpose, background, and general approach to the study are presented first. Then the following section provides a detailed explanation of the approaches proposed for the various individual study tasks. Discussions of Quality Control/Quality Assurance and reporting format are then presented, followed by a list of pertinent references. A technical description of the wastefield transport model, a key element of the study, is attached to the study plan.

PURPOSE

The study addresses the verification of models used to determine the permitted zone of mixing (ZOM) for the JCO. The purpose of this study plan is to describe the proposed approaches for: [1] using field data to verify the previous analyses of the fate and transport of cannery effluent, and [2] developing an evaluation effects of the discharge on dissolved oxygen (DO) concentrations throughout Pago Pago harbor.

BACKGROUND

The JCO is a new outfall operated by StarKist Samoa, Inc. and VCS Samoa Packing Company. The outfall discharges treated wastewater from the canneries into outer Pago Pago Harbor. The JCO replaces two separate outfalls that previously discharged effluent into the inner harbor near the canneries. The canneries began discharging through the JCO in February of 1992. In addition, prior to initiating discharge through the new outfall, the canneries implemented high strength waste segregation in August 1991. The high strength waste is disposed of in a permitted ocean disposal site and does not influence the harbor.

The effects of high strength waste segregation and outfall discharge relocation on the water quality of the harbor were modeled by CH2M HILL (1991a). The size and location of the ZOM was based on environmental and engineering studies which included model predictions of the initial and subsequent dilution and the farfield transport processes (CH2M HILL, 1991a). Newly issued NPDES permits are based on the approved zone of mixing.

The NPDES permits require implementation of a receiving water quality monitoring program to determine compliance with water quality standards. The monitoring program includes analysis of water samples from 17 specified stations throughout the harbor. The objective of the monitoring program is to document water quality near the outfall discharge, near the zone of initial dilution (ZID), within the ZOM and at the ZOM boundaries, and at other locations throughout the harbor. Data collection for the monitoring program is conducted monthly by the American Samoa EPA. Monitoring reports documenting the water quality data are submitted to USEPA on a quarterly basis.

Two dye studies are also required as conditions of the permits to observe the fate and transport of the effluent plume. The first (non-tradewind season) of these dye studies was conducted on February 17, 1993. The second (tradewind season) is scheduled to be performed in September/October 1993.

The data collected from the water quality monitoring program and from the dye studies allow direct observation of the fate and transport of the discharged effluent. The NPDES permit requirements dictate that these data be used to verify the model predictions used in the earlier engineering studies for determining the ZOM and to evaluate the effects of BOD in the effluent on DO in the receiving water. This requirement is described in Part J of NPDES permit Numbers AS0000027 and AS0000019 as follows:

> *"Within three months after both dye studies have been completed, the permittee, cooperatively with {Star-Kist Samoa, Inc.; Samoa Packing Co.}, shall submit a study plan to USEPA and ASEPA that will discuss how the permittees will utilize the results from the monitoring data and from the dye studies to verify the models used in the determination of the mixing zones (the 30-second dilution zone, the ZID, and the ZOM). Also, the plan shall discuss how the permittee will examine the effects of* BOD_5 *in the effluent on Dissolved Oxygen (DO) in the receiving water, utilizing an appropriate model and one year's worth of ambient data. Upon*

> *approval of the study plan by USEPA and ASEPA, the permittee shall initiate the studies indicated and submit reports on a yearly basis. Reports shall summarize renewed predictions of dilution rates and the size, location, and movement of the plume based on the calibrated models*".

This study plan is being submitted to the U.S. Environmental Protection Agency (USEPA) and American Samoa Environmental Protection Agency (ASEPA) to comply with the permit conditions.

APPROACH

The study is divided into two primary tasks:

- **Model Verification.** The modeling procedures used to establish the ZOM will be evaluated based on data collected during the dye studies and the water quality monitoring program.

- **BOD Impacts.** The effects of BOD (measured BOD_5) in the effluent on DO in the receiving waters will be evaluated.

The general approach to each of the major tasks is described below. A more detailed description of the methods to be used is described in the following section on Study Methods.

Model Verification

The basic approach used in the previous engineering study to determine the required mixing zone dimensions was to: estimate the large-scale, long-term average ambient receiving water concentrations using a wastefield transport model, evaluate initial and subsequent (or secondary) dilution for a range of conditions, and, based on model predictions, determine the appropriate location for the discharge and the required size of the ZOM to comply with American Samoa Water Quality Standards (ASWQS). This approach will be evaluated by running the models for the conditions present during the dye studies and water quality monitoring, as appropriate, and comparing the model results with the observed field data. The three separate subtasks identified above include:

- **Wastefield Transport Model.** Observed long-term average receiving water concentrations, on a harbor wide scale, for total nitrogen (TN) and total phosphorus (TP) will be based on concentrations observed at each of the water quality monitoring sampling stations. Average loadings of TN and TP to the harbor from the discharge will be calculated for the same period of time. The wastefield transport model will be run using these average loadings and evaluated by comparing the model results to the observed water quality data.

- **Initial and Subsequent Dilution Models.** The initial and subsequent dilution modeling procedures used to establish the mixing zone boundaries will be evaluated based on the dye study results. Model input will include measured currents, temperature and salinity profiles, and effluent flows present during each dye study. The model results will be compared to the dilutions observed during the dye studies and to previous predictions. The formulation of the effluent limits for ammonia were based on predicted diffuser performance in terms of initial dilution rate and magnitude. The predictions used for this purpose will be specifically evaluated as a part of this subtask.

- **Zone of Mixing Location and Size.** The ZOM location and dimensions will be re-evaluated if significant discrepancies between predicted and observed TN and TP values occur. Discrepancies will be addressed by recalibration of each model to match the observed data and running the re-calibrated models for a range of conditions representative of the worst case conditions expected in the harbor.

BOD Impacts

BOD impacts on receiving water DO will be evaluated using the same wastefield transport model, or an equivalent model, used to calculate ambient TN and TP concentrations. The impacts will be addressed using the verified (and possibly recalibrated) model discussed above to calculate the potential impacts of cannery effluent on DO levels throughout the harbor. A BOD/DO routine in the model will be used to simulate effects of various BOD loadings from the canneries discharge.

SCHEDULE

Sufficient information was collected from the first dye study to allow the formulation of this study plan. Therefore, the study plan is being submitted prior to the second dye study to facilitate coordination with the eutrophication study, also required as a NPDES permit condition. Coordination of the two studies will benefit both, but particularly assist in doing the eutrophication study. The proposed schedule is to have the report for initial model study finished and delivered to USEPA and ASEPA by May 31, 1994. The first report for the modeling study will include recommendations for subsequent annual reports as required in the permit condition. This schedule is based on the assumptions that the second dye study is carried out near the end of September or beginning of October 1993, and the water quality monitoring data are available by the end of 1993.

STUDY METHODS

This section provides a more detailed description of the approach summarized above. The major features of the methods used will also be discussed. The approach is designed to maintain consistency with the previous studies done to determine the appropriate outfall location and the size of the ZOM. The same models will be used, but the input conditions may be changed to reflect the data collected during the dye studies and the water quality monitoring program. Additional technical details concerning the models and previous model results can be found in the "*Engineering and Environmental Feasibility Evaluation of Waste Disposal Alternatives*" (CH2M HILL, 1991a), the "*Site Specific Zone of Mixing Determination for the Joint Cannery Outfall Project: Pago Pago Harbor American Samoa*" (CH2M HILL, 1991c), and the "*Environmental Impact Assessment for Joint Cannery Outfall Project, Pago Pago Harbor, American Samoa*" (CH2M HILL, 1991d and e).

MODEL VERIFICATION

Numerical model predictions used as the basis for defining the ZOM for the JCO addressed both the long-term effects of the discharge on the TN and TP levels throughout the harbor and the dilution and dispersion associated with initial and subsequent mixing processes in the vicinity of the diffuser. The long-term processes determine the average levels of the effluent constituents in the ambient receiving water of the harbor. These levels must be known to calculate constituent concentrations resulting from the initial and subsequent dilution processes. The ambient water is the diluting water for the initial dilution process and for an enclosed bay, such as Pago Pago harbor, the ambient concentrations are affected by the effluent discharge levels.

Verification of the previous model predictions will involve verifying predictions of long-term ambient constituent levels compared with levels measured during the water quality monitoring program, verifying initial and subsequent dilution predictions based on dye study results, and re-evaluation of constituent concentrations, if necessary, based on recalibrated models. Brief descriptions of the models used are included in the discussions below and more detailed technical information is referenced. Application of the various models to verify previous predictions and comply with the NPDES permit conditions are described below.

Wastefield Transport Model: Ambient Concentrations

Previous predictions of ambient conditions in Pago Pago Harbor because of the operation of the JCO used a wastefield transport model (PT121). This model is described in more detail in Attachment A and in CH2M HILL, 1991a. The model, developed by CH2M HILL, was based on a model originally developed by HRI (1989) for a wasteload allocation study of Pago Pago Harbor. The results were presented as a series of contour plots of TN and TP concentrations for a range of discharge loadings and alternative outfall sitings.

Water quality, effluent chemistry, flow data and additional oceanographic data collected since the outfall became operational will be used as input to the wastefield transport model. Long-term average TN and TP loadings from the cannery discharges will be calculated based on effluent monitoring data collected by the canneries for a period of at least one year. Loadings from other point sources (e.g. the Utulei Sewage Treatment Plant), nonpoint sources, and open ocean background (a boundary condition) will be estimated from available data. PT121, using the same geometry as used in the previous study (CH2M HILL, 1991a), and as calibrated for the previous study, will be run using the long-term average loadings.

Results will be presented in the form of contour plots of TN and TP throughout the harbor. These predicted concentrations will be compared to long-term average TN and TP levels measured at water quality monitoring stations over the same period of time. For comparison with predicted data, maximum, minimum and long-term average ambient concentrations will be determined for each of the station locations from quarterly water quality monitoring reports.

The previous model was calibrated for a data set based on discharges in the inner harbor. Some differences between model predictions and measured concentrations of TN and TP are expected. We anticipate the previous model results to be conservative (i.e. overpredict concentrations throughout the harbor). If necessary, the model will be recalibrated for the new location based on the available data. The predictions of the wastefield transport model, recalibrated if necessary, will be used for the re-evaluation of mixing zone location and size and for the BOD/DO evaluation described below.

Initial and Subsequent Dilution Models

Initial and subsequent dilution characteristics of the outfall were previously analyzed using the USEPA models UDKHDEN (Muellenhoff et al., 1985) for initial dilution and CDIFF (Yearsley, 1987) for subsequent dilution processes. The models were used to evaluate the diffuser performance and plume behavior for a range of effluent flow conditions for typical ambient receiving water conditions. The mixing zone characteristics were based on the worst case conditions.

UDKHDEN is a fully three-dimensional model that considers variable profiles throughout the zone of flow establishment and uses a fourth-order integration routine along the centerline of the effluent plume to trace plume position and dilution over time during the rapid initial dilution processes. The model predicts dilution (in terms of mixing with ambient water) and the trapping level of the effluent plume.

CDIFF is a passive diffusion plume model that can be applied following the momentum and buoyancy driven initial dilution process. Diffusion is calculated in the lateral direction only as the plume is advected in the longitudinal direction by ambient currents. The model allows specification of one of three functional forms for the coefficient of lateral eddy diffusivity (as a function of characteristic plume dimension). The model assumes the plume is trapped with a constant vertical extent or fully mixed over the depth of the water column. A constant current is assumed and the model accounts for a solid shoreline boundary parallel to the direction of the current.

The initial and subsequent dilution models will be run based on the as-built diffuser configuration and environmental and flow conditions measured during the dye studies. Input for the initial dilution model, UDKHDEN, will include: diffuser configuration (port size, port depth, and number and spacing of ports), temperature and salinity profiles, current profiles, and effluent flow and density. Temperature and salinity profiles were taken during the dye studies. The profiles taken nearest the diffuser will be used as representative of the conditions during initial dilution. A range of ambient currents will be selected based on the currents measured over the course of the studies. Initial and subsequent dilution model procedures used in the previous study will be repeated for the conditions observed during the dye studies.

Results of the dilution models will be presented as plots or tables of centerline and flux average dilution versus distance from the diffuser. The centerline dilutions observed during the dye studies will be compared to the predicted values. The dilution models are not easily calibrated without changes to the model code. However, a correction factor can be developed that relates model prediction to observation. This is functionally a calibration curve, and serves the same purpose as model calibration for a particular set of conditions. If required, correction or "calibration" factors will be developed and applied to model results. Corrected results will be applied to the re-evaluation of the mixing zone characteristics and the BOD/DO evaluation as described below. In addition, the results will be used to evaluate the effluent limits for ammonia (which are based on a ZID that depends on diffuser initial dilution performance), the predicted trapping level, and the size of the physical ZID.

Evaluation of Mixing Zone

If the difference between the model predictions and field observations for all three model predictions (wastefield transport, initial dilution, and subsequent dilution) is small the dilution models will not be recalibrated and re-evaluation of ZOM size and location will not be required. If it is determined that the model predictions are conservative (i.e. underpredict dilutions or overpredict the TN and TP levels) a qualitative description of the differences will be presented and the models will be recalibrated (or calibration factors developed) for use in the BOD/DO evaluation described below. If there is a significant discrepancy between the model predictions and field observations such that the models overpredict dilutions and underpredict TN and TP concentrations, the models will be recalibrated to minimize the differences between predicted and observed results and the size and location of the mixing zone will be re-evaluated.

Calibration of the wastefield transport model, if necessary, will be accomplished by varying the value of the diffusivity coefficient (K), varying the decay term for the constituent of concern, or a combination of both. The diffusion and decay coefficients can be varied along the longitudinal axis of the harbor. The previous analysis assumed a zero decay and the calibration of the model was based solely on varying K. The model configuration used different values of K for the inner and outer harbor. The dilution models will be calibrated, if necessary, primarily by varying the coefficient of lateral diffusivity in CDIFF and developing calibration factors for UDKHDEN and CDIFF as described above.

BOD/DO EVALUATION

The effects of BOD loadings in the cannery effluent on DO throughout the harbor will be evaluated using PT121, recalibrated if necessary, as described above, or using EPA's water quality model WASP4 (Ambrose et al., 1988). PT121 has been modified to include a routine developed to simulate BOD and DO interactions. The model is formulated for depth averaged applications and is useful for looking at long-term or slowly varying effects averaged through the water column. However, the available information on water column constituents in general (HRI, 1989; CH2M HILL, 1991a) and on dissolved oxygen in particular (CH2M HILL, 1991b) indicates that the water column can best be described as a two or three layer system. This effect is relatively small for TN and TP but may be significant for DO. Therefore, PT121 may be modified, or run in appropriate configurations, to simulate a multilayer system or WASP4 will be used for this evaluation. The decision on which model to use will be based on a review of available data and the extent of modifications required for PT121.

The model will be run for two kinds of simulations: an average long-term simulation such as that done for TN and TP as discussed above and for a representative time history of BOD inputs from the cannery discharges representing a worst case scenario. BOD_5 loadings based on available effluent chemistry data and observed DO levels from available water quality monitoring data will be used to calibrate the model. The horizontal and vertical diffusivities, decay of BOD and utilization of DO, consumption of DO other than by BOD, and re-aeration coefficients will be adjusted to achieve calibration. Other point and nonpoint sources of BOD will be identified if possible, however this "background" will be generally included as an additional calibration coefficient representing some elevation above open ocean background (included as a boundary condition). The calibrated model will be verified using a separate data set.

The wastefield transport model (PT121 or WASP4) can not be used to evaluate DO impacts within or in the immediate vicinity of the effluent plume. Therefore, results from the initial and subsequent dilution models will be applied to evaluate the nearfield effects within the effluent plume. This procedure will use the results of the wastefield transport model to provide ambient receiving water values as in the case of TN and TP described above. Measurements of immediate dissolved oxygen demand (IDOD) of the combined effluent from both canneries will be made in the field during the second dye study. The measured value of IDOD will be used for evaluation of the effects of BOD in the plume as it mixes with receiving water.

QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control will be achieved through use of the accepted and proven models executed by staff familiar with those models. Specific QA/QC measures include: validation, calibration and verification of models with field data, addressing a range of potential conditions where appropriate, sensitivity analyses, and documentation and maintenance of input and output files generated during modeling activities. A significant portion of the modeling effort is directed at keeping a high level of confidence in the predictions of the models. The purpose and scope of this effort and a description of the techniques that will be used are described below. There is often confusion and misunderstanding about the technical terminology used in this process. To avoid confusion the functions described as validation, calibration, and verification are defined below.

The purpose of the QA/QC effort is to provide a high level of confidence that the models are providing physically realistic predictions. There are two efforts required: first, it is important that the model configuration developed for the harbor be calibrated and verified (tested against site specific data) and, second, it is just as important that the basic model code be based on sound physical assumptions (the underlying science and mathematical formulation are accurate reflections of reality).

Validation. The models employed in the study are mathematical representations of physical processes. The mathematical equations used are solved numerically (approximate solutions) using a digital computer. It is important that this process, which is considerably removed from the actual physical processes and behavior of the harbor, accurately simulate what happens in the harbor. The process of validation uses representative parameters for simplified system configurations to determine if the predictions reflect reality. The process of validation begins as the initial model computer code is written and continues as long as the model code is used. It is particularly important that any changes in model code be checked for validity. The final element of validation is a determination of how sensitive a model is to changes in input parameters. An extremely sensitive model probably does not provide results with a high confidence level. Sensitivity checks will be carried out for each of the models for potentially critical parameters.

Calibration. Most numerical models of the type used here contain coefficients (e.g. friction factors, diffusion coefficients) that are often study site specific. Although there are generally accepted values for these coefficients, the range observed in nature is high and the models can be somewhat sensitive to the values selected. The process of calibration uses measured values of forcing functions and responses to determine the appropriate coefficients for the model configuration at the study site. Typically a set of field data, say water level, will be measured and the appropriate coefficient, in this case friction factor, will be varied until the model results match the observed results for the observed forcing function and model geometry.

In the case of the initial dilution model and, to a lesser extent, the subsequent dilution model, it may be inappropriate to modify the original model code. These models are intended for general use by EPA and consistency is an important consideration. In this case it is more appropriate to develop a correction factor or calibration curve to be applied to the results of the model. This process is similar to the development of calibration curves routinely developed for instrument read-outs or data measurements.

Verification. It is possible to "force" a model to reproduce observed results by means of calibration. Successful calibration does not necessarily mean that the model is operating correctly under other conditions. Verification is a check that utilizes an observed data set independent from the one used for calibration. Typically the calibrated model is run under different environmental conditions, say loadings of TN from the discharges, and the response of the model, in this case TN concentrations at selected points in the harbor, is compared to observed concentrations at those points. Verification, combined with validation and sensitivity determination, provides a high level of confidence that the model is simulating the system under a range of conditions.

Model Code Modifications. Model code modifications may be required for a variety of reasons. No modifications are planned for the primary algorithms except for possible revisions to PT121 as described above. Some minor changes in program structure to increase ease of use will probably be done. All model code changes will be documented and tested.

DATA ANALYSIS AND PRESENTATION

A report documenting the results of all analyses will be presented to EPA and ASEPA. The report will include summaries of all input data, modeling procedures, model calibration and verification, and model results. All pertinent model results and output files (as appropriate) will be reproduced as an appendix to the report. Model results will be presented both in tabular form and graphically (i.e. contour plots) as appropriate. The report will include: an executive summary; an introduction describing the background, rationale, and general approach of the study; a description of the methods used including model formulation and input data; a description of the model results; an evaluation of the model validity for predicting dilution and plume characteristics; an evaluation of the ZOM characteristics; and an evaluation of BOD impacts.

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ATTACHMENT A

PT121 Model Description

PT121 is based on the HARBOR model used for the Wasteload Allocation Study (HRI, 1989). The wasteload allocation study should be referenced for more information on the basic physical principles and model approach.

PT121 is a quasi-two-dimensional (Q2D) completely stirred tank reactor (CSTR) model. The term Q2D refers to the following model attributes:

- It is a two-dimension horizonal approach that is depth-averaged. There is no variation of any variable with depth. However, the depth does vary throughout the harbor model. It is not a constant-depth model.

- The model is set up in a grid that is laterally symmetric about the longitudinal axis of the model. The longitudinal axis is transformed into a straight line.

- The model grid is set up in two levels. Square cells of constant dimension are used for the calculation of concentrations and transport in both horizontal directions. Rectangular "line cells" are composed of integral numbers of cells in a line perpendicular to the harbor axis. These line cells form the basis for calculating total flow rates in the longitudinal direction and the input of nonpoint source flows and pollutant loading.

- Lateral advective flows are symmetrical about the longitudinal axis, and there is no advection across the longitudinal axis. These flows are calculated on the basis of mass conservation. Longitudinal advective flows are equally divided between individual cells in a line cell, with the provision of no flow through a solid boundary.

- Flow rates are on the basis of changes in volume due to tidal elevation changes. The water surface is considered to change instantaneously throughout the system. Tides are input in tabular form. Thus, longitudinal flows are calculated on the basis of conservation of mass.

- Point source flows and loadings are added to individual cells. Nonpoint source flows and loadings are added to line cells and are equally distributed to cells within the line cell.

- Diffusion coefficients and decay rates can vary along the longitudinal axis of the system but are constant within a line cell. Diffusion is the same in both horizontal directions.

- Diffusive transport is calculated as a Fickian process based on eddy diffusivity. This transport is calculated on a cell-by-cell basis with no transport allowed through a solid boundary.

The term CSTR refers to the following model approach to calculating concentration:

- The total mass of a constituent is calculated from the concentration and cell volume for each cell.

- On the basis of tidal data, the volume of the cell is changed.

- Advective transport is allowed to carry mass to and from adjoining cells on the basis of the concentration, flow rate, length of the time step, and area between the cells. The area is based on the average depth of the two cells and cell width.

- Diffusive transport carries mass between cells on the basis of concentration gradient, area between adjoining cells, and the length of the time step.

- Point source loadings are introduced into appropriate cells. Point source flows are also introduced into individual cells. The mass of constituent and volume of water are based on loadings, flows, and length of the time step.

- Nonpoint source inputs are calculated the same way as point source inputs, but each cell in a line cell has equal inputs.

- The original mass in each cell is allowed to decay on the basis of the specified first order decay constant and the length of the time step.

- Each of the inputs and outputs of mass into each cell is added to the initial mass less the amount of decay, and a new concentration is calculated.

PT121 is run by supplying the required instructions and parameters by means of input files read by the program as it executes. The model is written and compiled in TurboBasic on an IBM-compatible computer operating under

MSDOS. The input is in four separate files. The job control file provides input for:

- Input/output file names
- Size of model grid (number of cells)
- Time step length
- Horizontal cell dimension
- Where to start reading from tide data file
- Number of days to do calculations
- Number of point sources considered
- Amount of tidal data to be read
- Input/output control parameters
- Cells where point source loadings are found
- Point source loadings and flows

The hydrodynamics file provides input for cross-sectional area, width, and nonpoint source flows as a function of distance along the harbor (for each line cell).

The tidal data file provides input for tidal elevation as a function of time in tabular format. The water quality/geometry data file provides input for the following parameters and variables:

- Initial concentration as a function of distance along the harbor, and boundary concentration at the open end of the harbor.

- Eddy diffusion coefficient as a function of distance along the harbor.

- Decay rate coefficient as a function of distance along the harbor.

- Nonpoint source loading as a function of distance along the harbor.

- Definition of the cells constituting the side boundaries of the system.

- Depth of each cell at the appropriate tidal elevation.

- Definition of the boundary condition for each of the boundary cells of the system.

The model results are provided in three optional output files as specified in the job control input file. These files are described below, and example output to a printer is shown. The files consist of a "mirror file" that primarily presents the input, a hydrodynamics file that provides results of the flow calculations, and a water quality output file that provides the results of the transport calculations.

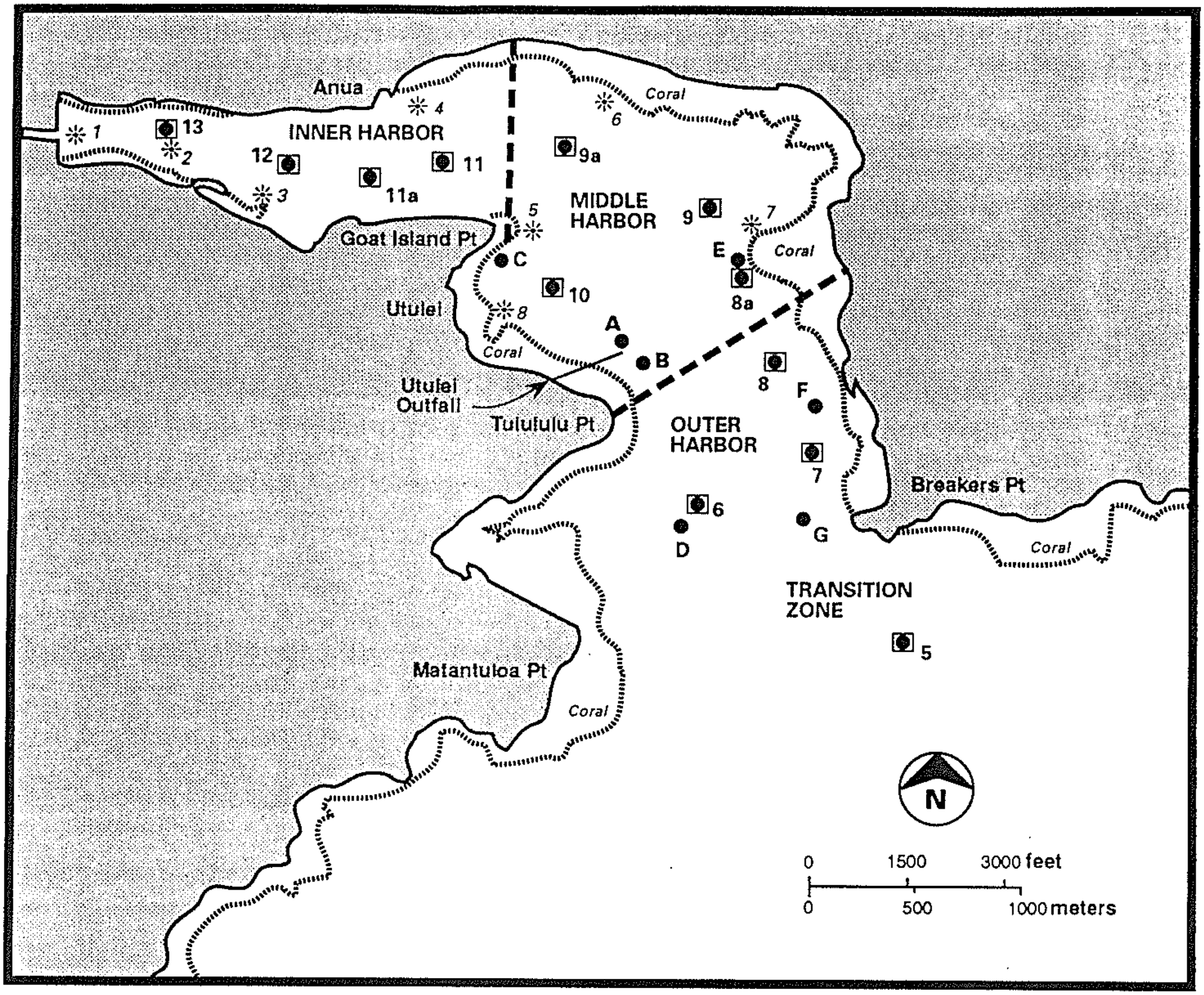
The mirror file provides a listing and tabulations of the input values read and initially manipulated by the program. The primary function of this file is to provide documentation and allow the operation of the program to be checked. The file is generally used for validation runs and is switched off during production runs. The mirror file has the following parts:

- A title page that provides a description of the important program and model control parameters
- A summary of hydrodynamic and geometric data
- A tabulation of the tidal data used by the routine
- A tabulation of water quality inputs including initial concentrations, diffusivity and decay coefficients, and loadings
- A tabulation of cell depths that are input in feet and converted to meters
- A table of boundary conditions. The significance of the various boundary conditions can be determined by reference to the model code

The hydrodynamics file is also generally used for program validation and is switched off during production runs. This file contains a tabulation for each time step of the change in volume, flow rate, cross-sectional area, and velocity for each line cell or line cell boundary.

The water quality output file gives a description of the concentration at the end of each time step in each cell. The output interval for both the hydrodynamics and water quality output files can be specified if each time step is not desired.

TO	Name :	WALT FRICK	
	Organization :	ERL-NEWPORT	
	Mail Stop :		
	Fax No. :	Area Code 503	Number 867-4049
	Verification No.:	Area Code 503	Number 867-4029
FROM	Name :	DAVID STUART	
		U.S. Environmental Protection Agency Region 9 75 Hawthorne Street San Francisco, California 94105	
	Branch/Section :	WQE/MPS	
	Division :	WMD	
	Mail Stop :	W-7-1	
	Phone No. :	Area Code 415	Number 744-1168
	Fax No. :	Area Code 415	Number 744-1070 FTS 484-1070
	Verification No.:	Area Code 415	Number 744-1079 FTS 484-1079
DATE	8/16/93		
PAGES	(Including Cover) 11		
SUB-JECT	PAGO PAGO HARBOR AMBIENT CONDITIONS		
NOTE			



PDX30702.UA Loc of Water Qual Stations 3-4-91mms

LEGEND

ASG Sampling Station

Utulei WWTP Station

CH2M HILL Field Measurement Station (1/19/91)

Figure 5
Location of Water Quality Stations

PDX30702.UA Coral Reef Transects 3-5-91mms

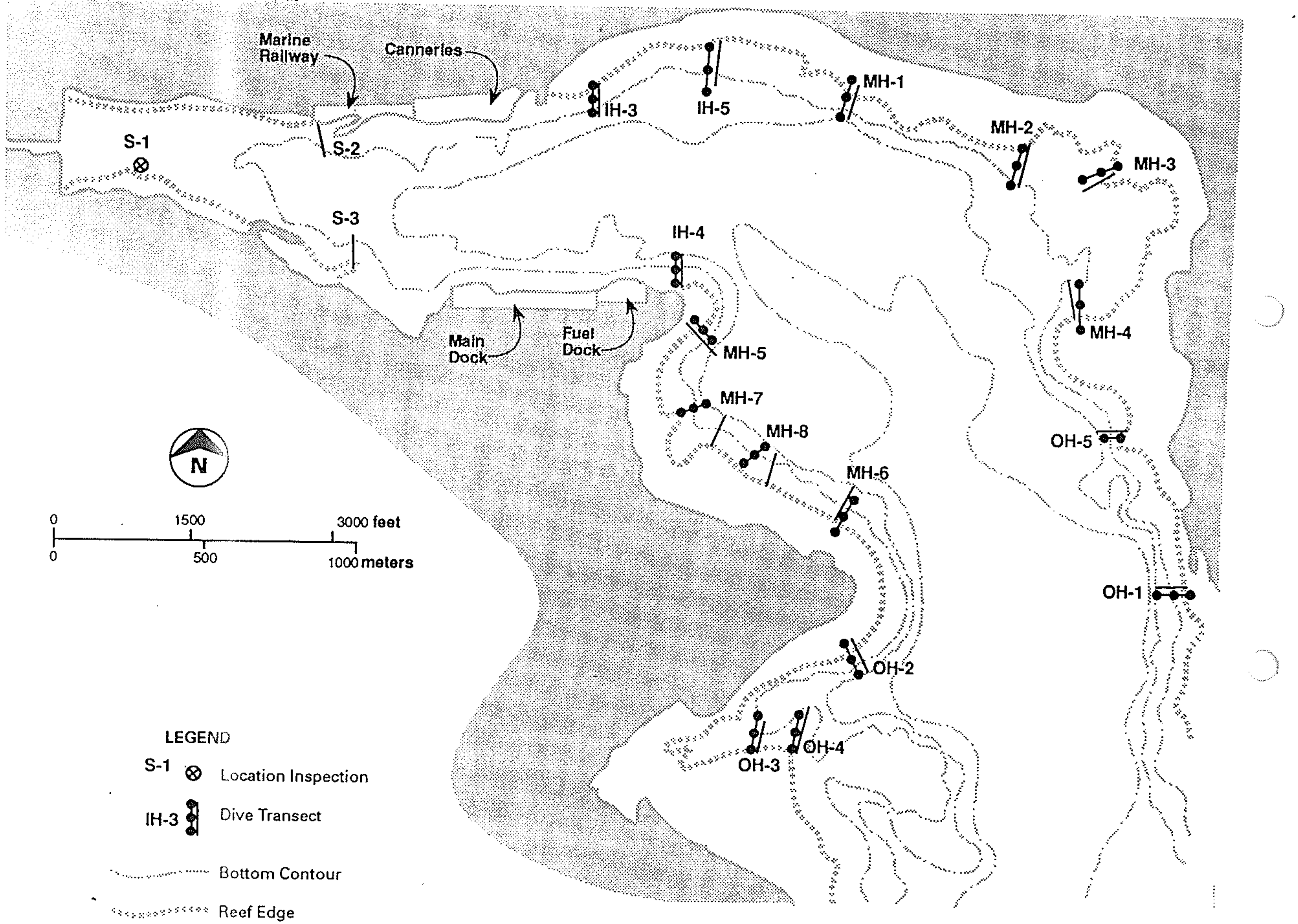


Figure 4
Coral Reef Transects in

Table A8. Pago Pago Harbor Water Quality Survey - 1/19/91.

Station WQ8 - Near Utulei Between Transects MH7 & MH8

Depth, m	Temperature, Celsius	Dissolved Oxygen, mg/L	Salinity, ppt
0.3	29	7.3	32.5
1	28.5	7.6	32.5
2	28.5	6.9	32
4	28.5	6.7	32
7	28	6.4	32
10	28	6	32

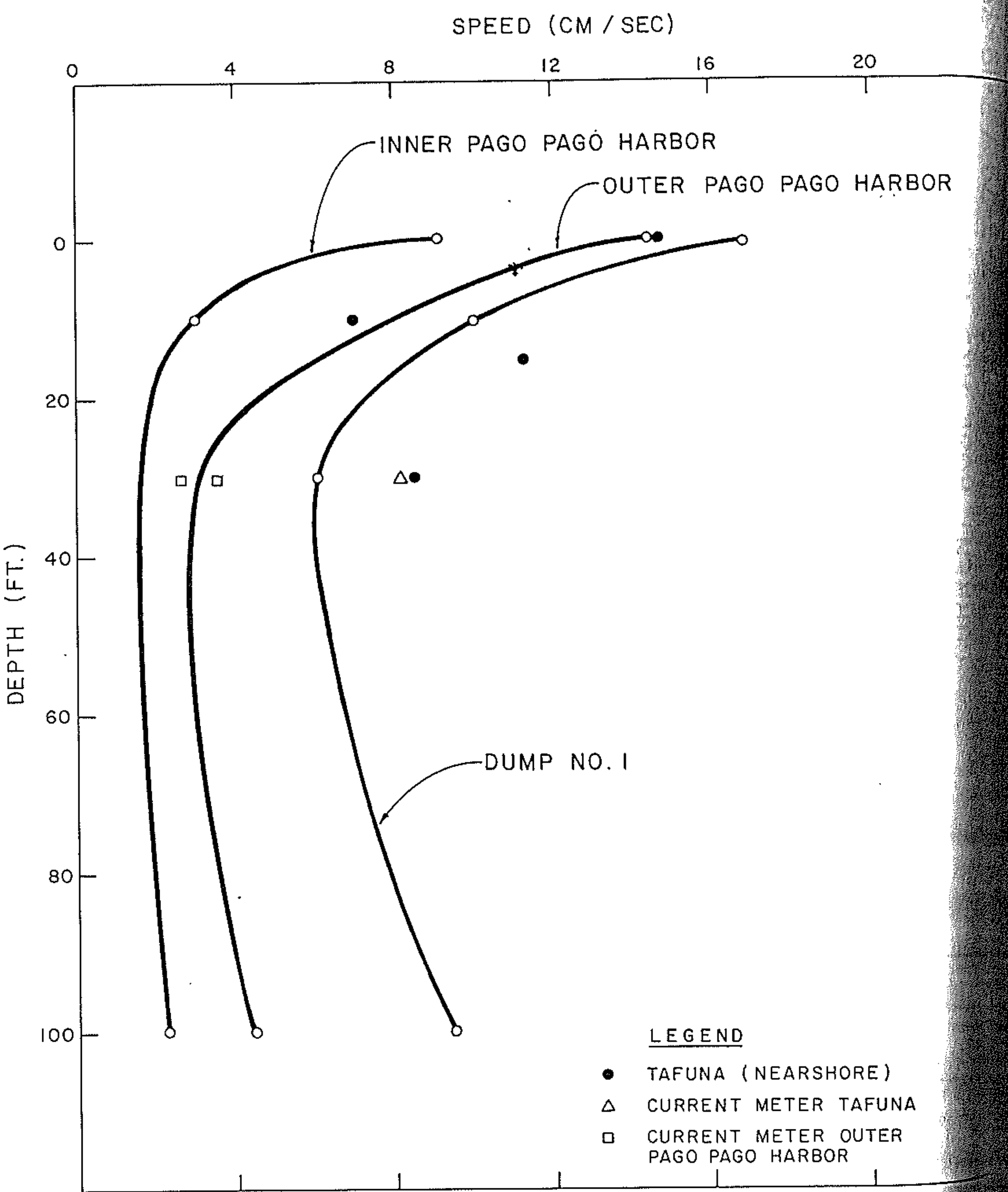


FIGURE V-11

AVERAGE CURRENT SPEED VARIATION WITH DEPTH AND LOCATION

Table A-2, Cont.

Date	Station No. (Location)	Depth (ft)	Relative Irradiance (%)	Salinity (o/oo)	Temp. (°C)	D.O. (ppm)	Turbidity (NTU)	pH	Suspended Solids (mg/1)	Fecal Coliform (#/100 ml)
7/11/79	8 (Pago)	Sur	45	33.27	28.00	7.35	0.43	8.35	2.0	<1
		5	25	33.27	27.90					
		10	22	33.27	27.90					
		20	7	33.37	28.00					
		30	5	33.45	28.00					
		40	1.9	33.47	28.00					
		50	1	33.47	27.98	6.25				
		60	–	33.47	28.00		0.28	8.30	1.1	
		70	–	33.47	28.00					
		80	–	33.47	28.00					
		90	–	33.47	28.00					
		100	–	33.47	28.00					
7/11/79	9 (Pago)	Sur	55	33.07	28.20	7.35	0.47	8.32	1.7	<1
		5	35	33.07	28.20					
		10	25	33.15	28.10					
		20	4	33.22	28.00					
		30	1.8	33.47	28.10					
		40	1@35'	33.47	28.10					
		50	–	33.47	28.08	5.90				
		60	–	33.45	28.10		0.32	8.32	1.0	
		70	–	33.47	28.00					
		80	–	33.47	28.00					
		90	–	33.47	28.00					
		100	–	33.47	28.00					

Date	Station No. (Location)	Depth (ft)	Relative Irradiance (%)	Salinity (o/oo)	Temperature (°C)	D.O. (ppm)	Turbidity (NTU)	pH	Suspended Solids (mg/1)	Total Coliform (#/100 ml)	Fecal Coliform (#/100 ml)
2/19/79	8 (Pago)	SUR	-	33.00	28.00	6.1	0.49	8.13	2.8	< 2	< 2
		5		33.90	28.50						
		10		34.60	28.60						
		20		34.60	28.60						
		30		34.60	28.70						
		40		34.60	28.65						
		50		34.60	28.60	5.8					
		60		34.60	28.60		0.25	8.17	1.9		
		70		34.60	28.60						
		80		34.60	28.60						
		90		34.60	28.60						
		100		34.60	28.60						
2/19/79	9 (Pago)	SUR	-	28.70	26.90	5.6	1.60	8.00	3.1	< 2	< 2
		5		29.60	27.10						
		10		34.60	28.70						
		20		34.60	28.70						
		30		34.60	28.65						
		40		34.60	28.65						
		50		34.65	28.60	5.9					
		60		34.65	28.60		0.20	8.17	1.6		
		70		34.65	28.65						
		80		34.65	28.65						
		90		34.65	28.65						
		100		34.65	28.65						
/19/79	10 (Pago)	SUR	-	32.40	27.90	5.9	0.55	8.12	2.2	< 2	< 2
		5		34.00	28.40						
		10		34.60	28.70						
		20		34.60	28.70						
		30		34.60	28.70						
		40		34.60	28.70						
		50		34.64	28.70	5.7					
		60		34.65	28.70		0.43	8.17	3.5		
		70		34.66	28.70						
		80		34.66	28.70						
		90		34.66	28.70						
		100		34.66	28.70						

Date	Station No. (Location)	Depth (ft)	Relative Irradiance (%)	Salinity (o/oo)	Temperature (°C)	D.O. (ppm)	Turbidity (NTU)	pH	Suspended Solids (mg/1)	Total Coliform (#/100 ml)	Fecal Coliform (#/100 ml)
2/14/79	9 (Pago)	SUR	50	33.50	29.40	6.15	0.41	8.34	-	<1	<1
		5	30	34.30	29.10						
		10	25	34.40	29.10						
		20	10	34.50	28.90						
		30	15	34.50	28.80						
		40	8	34.55	28.70						
		50	4	34.55	28.70	5.9					
		60	2	34.60	28.70		0.18	8.33	-		
		70	1	34.60	28.70						
		80		34.60	28.65						
		90		34.60	28.65						
		100		34.60	28.65						
2/14/79	10 (Pago)	SUR	40	33.90	29.70	6.3	0.66	8.36	-	<1	<1
		5	20	34.00	29.60						
		10	13	34.00	29.10						
		20	9	34.55	28.90						
		30	6	34.55	28.80						
		40	4	34.60	28.80						
		50	2.5	34.60	28.80	5.8					
		60	1	34.60	28.80		0.21	8.33	-		
		70		34.60	28.80						
		80		34.60	28.75						
		90		34.60	28.75						
		100		34.60	28.70						
2/[illegible] 79	11 (Pago)	SUR	60	34.00	29.80	6.55	0.77	8.38	-	<1	<1
		5	20	34.10	29.75						
		10	8	34.30	29.35						
		20	6	34.50	29.00						
		30	5	34.55	28.90						
		40	4	34.55	28.85						
		50	2.5	34.60	28.80	5.85					
		60	1	34.60	28.75		0.25	8.33			
		70		34.60	28.75						
		80		34.60	28.70						
		90		34.60	28.70						
		100		34.60	28.70						

Mixing Zone Determination from the EQC. This was originally granted in 1986 and ASPA will submit an application for renewal. The Utulei STP discharge has remained in compliance with the existing mixing zone, and it is ex that this will be renewed. (Personal Communication, S Wiegman, Environmental Quality Commission, December 19

III. TECHNICAL EVALUATION

A. Physical Characteristics of Discharge [40 CFR 125.61(a)]

1. What is the lowest initial dilution for your curren and modified discharge(s) during 1) the period(s) of maximum stratification? and 2) any other critical period(s) of discharge volume/ composition, water quality, biological seasons, or oceanographic conditions?

Diffuser characteristics and initial dilution remain the same as the original section 301(h) modified permit for the Utulei STP.

Calculations result in a minimum initial dilution of 297:1 for the Utulei outfall. The EPA initial dilution model, PLUME, was used to obtain this figure. Trapping depth was predicted to be 2.91 m (9.54 ft) below the surface.

2. What are the dimensions of the zone of initial dilution for your modified discharge(s)?

Zone of initial dilution (ZID) dimensions are calculated to be a cylinder 42 m (140 ft) in height and 84 m (240 ft) in diameter with the outfall terminus being the center. The simplified method described in the "EPA Revised Section 301(h) Technical Support Document", section V, was used to calculate ZID dimensions.

3. Will there be significant sedimentation of suspended solids in the vicinity of the modified discharge?

Using Figure III-3 of the "EPA Revised Section 301(h) Technical Support Document" and the 200 projected mass emission rate of suspended solids for the Utulei STP of 1607 kg/d, based on proposed effluent limits and the predicted plume height of rise of 9.54 m (128 ft), the resulting steady state accumulation is well below 50 gm/m^2. Biological effects appear to be minimal when accumulation rates are projected to below this level.

B. Compliance with Applicable Water Quality Standards [40 CFR 125.60(b) and 125.61(a)]

TABLE V-1

ESTIMATED OVERALL RESIDENCE TIMES IN PAGO PAGO HARBOR WITH RESPECT TO THE TRANSITION ZONE

Area	Residence Time with Average Tidal Exchange Only (days)	Residence Time with Average Tide and Average Wind Exchange (days)
Outer Harbor	19.5	12.9
Inner Harbor	34.3	18.1

When stratification is considered, then the average estimated residence times given in Table V-2 are applicable.

TABLE V-2

ESTIMATED AVERAGE RESIDENCE TIMES WITH RESPECT TO THE TRANSITION ZONE OF THE UPPER AND LOWER LAYERS OF PAGO PAGO HARBOR

Area	Residence Time with Average Tidal and Wind Exchange (days)
Outer Harbor Upper Layer	6.8
Outer Harbor Lower Layer	14.9
Inner Harbor Upper Layer	9.5
Inner Harbor Lower Layer	24.6

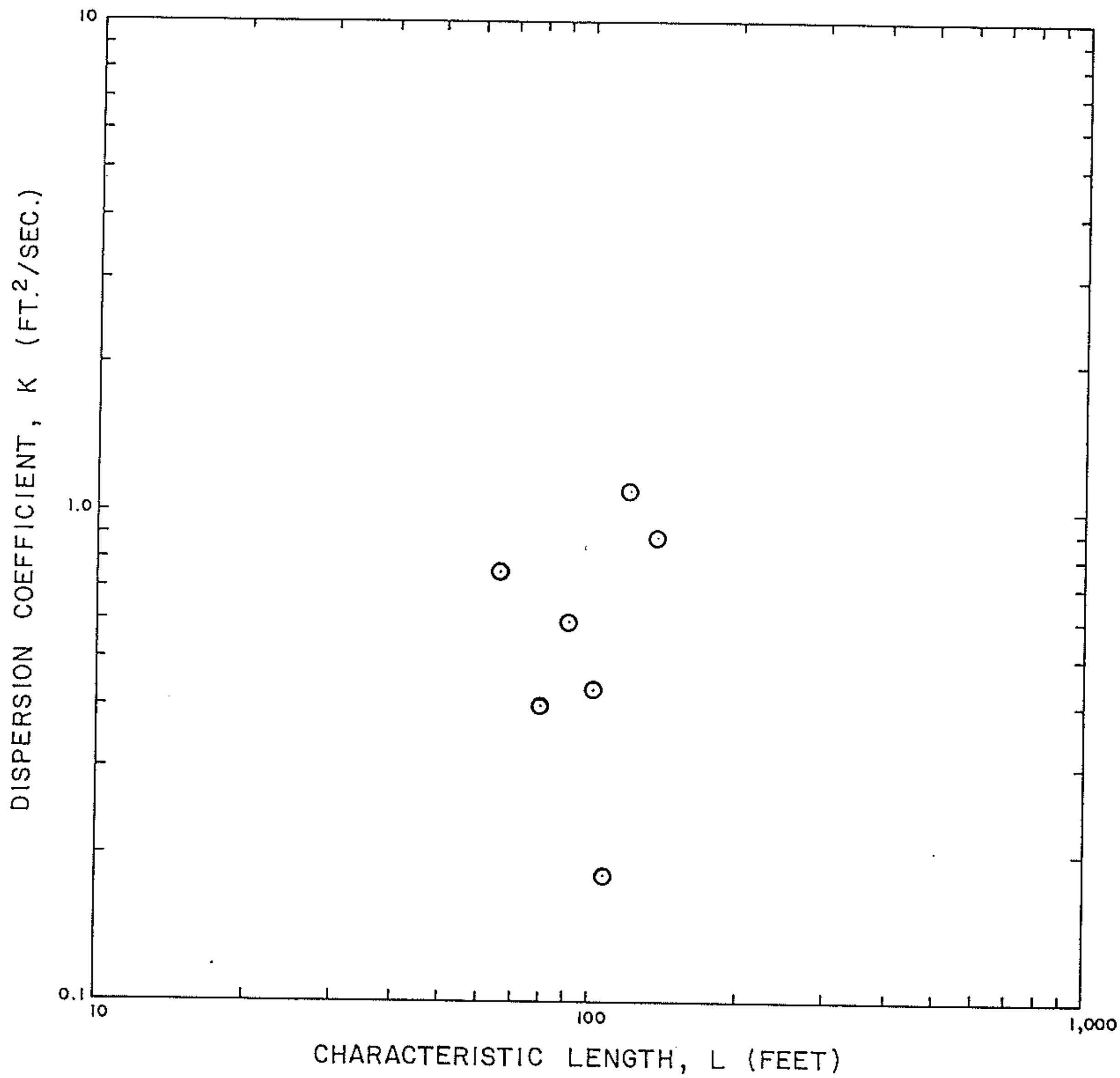


FIGURE V-13

DISPERSION COEFFICIENT VS. CHARACTERISTIC LENGTH FOR OUTER PAGO PAGO HARBOR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL RESEARCH LABORATORY - NARRAGANSETT
HATFIELD MARINE SCIENCE CENTER
NEWPORT, OREGON 97365

December 14, 1995

MEMORANDUM

PACIFIC ECOSYSTEMS BRANCH
TELEPHONE: (503) 867-4040

SUBJECT: Joint Cannery Outfall Model Prediction Verification Study Review

FROM: Walter Frick Walter E Frick

TO: David Stuart

Regarding your memo to Henry Lee dated September 22, 1995, which was forwarded to me after some delay, I have talked to Ed Dettmann (401/782-3039) about the issues surrounding the use of WASP5. I made the following notes of my conversation with Ed:

> WASP is a suite of models ranging from one to three dimensional, i.e., it can be run at several levels of complexity ranging from DO Streeter-Phelps equations, to solving nutrient concentrations (e.g., ammonium to nitrate conversion), to, at the highest level, calculating phytoplankton biomass concentrations. In the case of the canneries, DO would be a problem.
>
> WASP, including WASP5, must be matched with a hydrodynamic model. Within EPA the model used for this purpose is often DYNHYD, which is a one-dimensional hydrodynamic model. For three-dimensional circulation, presumably some other model or set of data would have to be used to define three-dimensional transport.
>
> Individuals in the agency familiar with WASP are Ed Dettmann at Narragansett and Mike Marsh at Region 1 (410/742-3115).
>
> Ed has used WASP do calculate DO concentrations in a river estuary with freshwater input. There they used salinity data and a salinity driven box model to estimate transports necessary to establish the observed salinity distribution. Thus, advection and diffusion were calculated. The approach is steady state and salinity survey data must be available. It does not work without freshwater inflow to establish a salinity distribution.

From the text on page 5-6 of the Study it seems to me that the authors are looking to WASP5 to provide three-dimensional hydrodynamical data. If this is the case, my understanding is that it will not be a three-dimensional replacement for PT121.

Other than that, I have no objection to trying to understand the dynamics of eutrophycation in the Pago Pago Inner Harbor and believe that, given data on the three-dimensional circulation in the harbor, that WASP5 can be used appropriately.

cc. Henry Lee